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Review

PREDICTION OF LIVE BODY WEIGHT FROM HEART GIRTH MEASUREMENT FOR SMALL RUMINANT IN ETHIOPIA: A REVIEW ARTICLE

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This review paper would highlight different methods used in estimating live body weights of small ruminants and serves as a weight-taking guide to village farmers, extension agents, researchers as well as the small ruminant clinicians. Body weight of animals varied as a function of breed, feeding, health, sex, age and management situation under which the animals were kept. Knowing the live bodyweight of small ruminants is important for a number of reasons, such as for breeding, correct feeding medication, marketing and replacement of male and female animals in the herd. Under Ethiopian condition most of small ruminant were reared under smallholder and traditional production systems. Under such situation, it is difficult to measure body weight of animals because of lack of weighing balance and its difficulties during measurements. Under such situation, the animal live body weight of small ruminant can be predicted from different linear body measurements, which have high correlation with body weight. Among linear body measurements heart girth have high correlation with body weight and body weight of small ruminant were predicted from heart girth for specific breed, age and sex of animals.

Key words: Body weight, Heart girth, Regression model, Small ruminant.

INTRODUCTION

The knowledge of livestock weight assessment remains the backbone on which all animal production management practices are hinged (Otoikhian et al., 2008). Traditionally, animals are visually assessed, which is a subjective method of judgment (Abanikannda et al, 2002). To overcome many of the problems associated with visual evaluation the development of objective means (linear body measurements) for describing and evaluating body size and conformation characteristics is important (Jimcy et al., 2011; Yakubu and Ibrahim, 2011). Apart from avoiding, the errors of visual determination of animal weights, non-skilled/rural stockman that make up the higher percentage of small ruminant holders, need a reasonable and simple skill in estimating weight when a weigh bridge cannot be assessed. Animal

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live body weight is an important feature, but can seldom be measured in rural areas and animal markets due to lack of weighing balance facility. The sale and purchase of animals is done by bargaining or based on their physical appearance. In this fake method of marketing, the farmers cannot get the exact price of their animals. This implies that the intermediary earned major part of profit.

Under standard conditions, properly calibrated livestock scales are the most accurate and consistent method for determining body weight. Under farm conditions however, where scales and records may be absent, it may be difficult to know the weight of sheep and goats (Solomon and Kassahun, 2009). Some of these standard weighing scales coupled with their shortcomings are too expensive for most of small farmers (Mahieu, 2011). This has forced many farmers to rely on estimates of body weights using certain number of body characteristics that can be measured readily (Alade et al., 2008).

Morphological traits have been used in animals to estimate body weight (Yakubu, 2010a). This has largely been the case in rural communities where scales are not readily available. The common measures of estimation of body weights has been simple correlation coefficients between body weight and morphometric measures or regression of body weight on a number of body measurements (Kuzelove et al., 2011).

The weight of sheep/goats fluctuates because of management system, pregnancy, gut fill, lactation, etc. Measurements of various body conformations are of value in judging quantitative characteristics of meat and developing suitable selection criteria. Moreover, because of the relative ease in measuring linear dimensions they can be used as an indirect way to estimate weight (Getachew, 2008, ESGPIP, 2009).

Proper measurement of live body weight, which often is hard in the village settings due to lack of weighing scales, is a prerequisite for achieving so many lofty goals that are always associated with either medical or economic status of the animals. Knowing the live bodyweight of small ruminants is important for a number of reasons, such as for breeding, correct feeding and health, marketing and replacement of male and female (Slippers et al., 2000; Mekonnen and Biruk, 2004; Adeyinka and Mohammed, 2006; Kunene et al., 2009; Oke and Ogbonnaya, 2011). Apart from taking live weight of meat animals, researchers also use other parameters such as body length, width of pelvis, height at withers and chest girths for adequate evaluating of live animals (Atta and Elkhidir, 2004). There were different works, which show the prediction of body weight from different linear body measurement for different location at different sex and age categories. Therefore, it is important to organize and summarize different works and make option of appropriate prediction model based on breed type, sex and age group for different decision-making. Therefore, the present paper was reviewed with objectives of identifying methods of body weight prediction from heart girth and procedures of linear body measurement.

CORRELATION BETWEEN BODY WEIGHT AND OTHER LINEAR BODY MEASUREMENTS

The correlation is one of the most common and useful statistics that describes the degree of relationship between two variables. Amongst body measurements, high correlation coefficient values have been found between chest girth and body weight (Bello, and Adama, 2012). In addition, the highest relationship among body measurements may be used as the selection criterion (Khan et al., 2006). The reports of Slippers et al. (2000); Badi et al. (2002); Grum (2010); Dereje (2011); Halima et al. (2012) and Yaekob et al. (2015) showed that chest girth was best parameter for estimating body weight due to high correlation estimates (Tables 1 and 2).

Measuring linear body measurement and precaution during measurement

Linear body measurement is a tool that enables the livestock producer to identify structural weaknesses and strengths that are genetic and thus inheritable. Thus, linear body measurement can be used as an indirect way to estimate body weight. It is necessary to measure linear body measurement early in the morning when animals have been locked in barns or pens overnight. This system would obviously suit Ethiopian conditions as all sheep and goats are generally housed or kraaled at night. To minimize the variation when full gut weight is taken, weigh at the same time of day each time and ensure consistent feeding and watering prior to each weighing. In addition, precautions like checking accuracy of scales against a known standard and avoiding human errors such as mistaken ear tag numbers or other animal identifications, mistaken

Table 1. Correlation between body weight and heart girth of sheep in Ethiopia.

Sheep breeds/local population	Coefficient of correlation (R^2)		References
	Female	Male	
Horro	-	0.86*	Kassahun (2000)
Horro	0.77*	0.85*	Zawdu (2008)
Abergelle	0.84*	0.79*	Seare et al.(2011)
Menz	-	0.9*	Kassahun (2000)
Menz	0.82*	0.91*	Getachew (2008)
Hararghe highland	0.94*	0.96*	Wossenie (2012)
Bonga	0.78*	0.88*	Zewdu (2008)
Afar	0.81*	0.86*	Getachew (2008)
BHS	0.91*	0.88*	Wendimu (2013)
Gumuz	0.77*	0.79*	Solomon (2007)
Local sheep of east Gojam	0.57*	0.65*	Michael (2013)
Local sheep of tigray highland	0.83*	0.86*	Alemayehu and Tika bo (2010)
Local sheep of north wollo	0.94*	0.98*	Tassew et al. (2015)

weight readings (ESGPIP, 2009).

Although live body weight is an important growth and economic trait, it is not always possible to measure it primarily due to lack of weighing scales, particularly in rural areas. However, body weight can be reasonably estimated from some linear body measurements (Singh and Mishra, 2004).

Under field conditions where scales are not available, body weight can be estimated using liner body measurements. Heart girths (HG), height at wither (HW) and body length (BL) are the most commonly used measurements (measured to the nearest centimeter) (Girma and Alemu, 2008). Linear body measurements are significantly affected by sex of the animals, age of the animals, breed type and types of birth (Fekerte, 2008).

Weight band: A weight band is a specially marked tape used to measure the heart girth and convert that measurement to accurate estimate of the goats/sheep live weight a procedure described by (De Villiers et al., 2010). Briefly, the weight band is wrapped directly behind the shoulder blade, down the fore-ribs, under the body behind the elbow and all the way around to the point behind the shoulder blade. The ends of the weight band are overlapped on top, on the goat's spine. Lastly, the resultant weight measurement is read off the weight band in kilograms.

Visual appraisal: This skill is developed through practice by estimating the weight of numerous animals without a board or weigh band. Visual determination of the weight of animals is often faced by errors like using the same estimate for more than one breed of a particular species (Otoikhian et al., 2008). Body structure can be deceptive when estimating weight (Slippers et al., 2000). For instance, Red Sokoto goats appear lighter than they actually are because of their light bones. Apart from bones and body structure problem in estimating weight, a white animal always looks bigger than it is (Otoikhian et al., 2008).

Body Linear Measurements: There are a number of linear dimensions, which can be used to quantify the size of an animal and to estimate weight. The most widely used body linear measurements include height at withers, heart girth, chest depth, body length, fore cannon bone, rump height, distance between eyes, ear length, ear width, paunch girth and tail length. Heart girth and cannon bone length are least affected by the posture of the animal. The report of Abegaz and Awgichew (2009) described that hearth girth measurement is one of linear body measurement used to estimate live body weight. Heart girth is a circumferential measure taken around the chest just behind the front legs and withers (Figure 1). The measurement should be taken to the nearest 0.5 cm. Heart Girth is a highly repeatable measure though it does vary somewhat with extremes of posture and perhaps as the animal breaths. There are many weight tapes that are available for estimating animal live weight, as there is a good correlation between chest circumference and body weight, within breeds, sexes, and ages of stock. The better association of body weight with chest girth was possibly due to relatively larger contribution of heart girth to body weight, which consists of bones, muscles and viscera (Thiruvenkadan, 2005). This indicates that reliable Heart Girth-live body weight relationships are obtained from mature animals. In excessively hairy small ruminants like Arsi Bale goats/gishe, make sure to compress the hair while measuring heart girth.

GENERATING BODY WEIGHT MODEL FROM HEART GIRTH

Usually, body weight is regressed on body

Table 2. Correlation between body weight and heart girth of goat in Ethiopia.

Goat breeds/local population	Coefficient correlation (R^2)		References
	Female	Male	
Begayit	0.89*	0.96*	Gebrekiros et al.(2016)
Hararghe Highland	0.94*	0.97*	Dereje et al.(2013)
Short-eared Somali	0.88*	0.84*	Grum (2010)
Short-eared Somali	0.73*	0.79*	Hulunim et al. (2015)
Woyito-Guji	0.86*	0.88*	Yaekob et al. (20150
Abergelle	0.88	0.91	Alemayehu et al. (20120
Bati	0.82*	0.85*	Hulunim et al. (20150
Borana	0.82*	0.86*	Hulunim et al. (20150
Local goat of bale zone	0.65*	0.75*	Belete (2013)
Local goat of shabelle zone	0.93*	0.97*	Alefe (2014)
Local goat of Nuer zone	0.91*	0.96*	Tsigabu (2015)

Figure 1. Heart girth measurement (Asefa et al., 2017).

measurements to determine a weight-prediction equation (Kashoma et al., 2011). Regression models allow as fast evaluation of the body weight of an animal and are used for the optimization of feeding, determination of optimum slaughtering age and as selection criteria (Yakubu et al., 2011). Regression model can be constructed based from linear body measurements based on sex and age of animals because linear body measurement can be varied based on sex and age of animals (Farhad et al., 2013). It is reasonable to suggest that there is need to develop different predictive models for different species or breeds of livestock by considering age, sex, management and local areas (Assan, 2013).

Depending on the design and types of variable, different statistical methods could be used to analyze the relationship between the live body weight and the body linear measurements. In most cases, the relationships between live body weight and linear measurements and among the linear measurements themselves are determined by the use of Pearson's Correlation Coefficients. The body weight would then be regressed on body linear measurements using general linear model and regression analysis to generate prediction models.

To determine the best fitted regression model in step wise regression, coefficient of determination (R^2), residual mean square(MSE), the Mallows C parameters C(P), Alkaike"s Information Criteria (AIC) and Schwarrz Bayesian Criteria (SBC) could be used to evaluate and compare different regression models generated (Snedecor and Cochran,1989). In addition, more than one linear measurement may be used in an equation to improve predictive ability as seen in the work of (Pesmen and Yardimci, 2008).

A stepwise multiple regression analysis was also carried out when other body measurements were added, one at a time, to heart girth. The essence was to determine how other body measurements would influence the precision of live weight predictions compared to using Heart girth alone (Afolayan et al., 2006). However, as we increase the number of variables in the model, it can cause complexity under farmer's level (yaekob et al., 2015). According to the report of Zewdu et al., (2009) on Bonga and Horro sheep and Getachew et al., (2009) on Menz and Afar sheep indicated that incorporating of more linear body measurement in the prediction equation has improved prediction accuracy.

This implies that considering more parameters of linear body measurements could provide better precision in predicting the body weight using the established equation. However, heart girth parameter is the easiest way, most appropriate and confident parameter to use for live weight prediction in field conditions especially under the smallholder farmers (ESGPIP, 2009; Getachew et al., 2009; Alemayehu and Tikabo, 2010; Alemayehu, et al., 2012). The report of Kunene et al. (2007) also shows that heart girth is the best single predictor of live weight. The following syntax was designed more of for the researchers to predict regression models from body measurements (heart girth and body weight). On the other hand, farmers, developmental agents and animal health experts were use the predicted formula for specific sex, age and breed types.

The syntax used for estimation of body weight from heart girth is as follows:

```
data kkk;
input heart girth cards;
(INTER DATA)
run;
proc reg data=kkk;
model BW= heartgirth/ vif;
run;
PROC REG data=kkk;
MODEL BW= heartgirth/ SSE CP AIC SELECTION=CP ;
RUN;
proc reg data=kkk;
model BW= heartgirth / selection=stepwise sle=.05 sls=.05;
plot student.*(ex1 x ed age u2);
plot student.*predicted. cookd.*obs.;
plot npp.*residual.;
run;
```

The prediction models of body weight from heart girth of some Ethiopian sheep and goat breed/ local population were presented in Tables (3 and 4). All the formulae were presented for matured breeds/ which contains all age groups/ pooled age categories. This canbe used as guideline for farmers/pastoralist to estimate weight of their animals without requiring sophisticated equipment.

Precautions while taking body linear measurements

Since the animal body movement and posture can introduce errors into measurements and estimated weights there should be appropriate procedure that one can follow. When measuring linear body measurement in general and heart girth in particular must choose measurements that are little affected by the animal's posture, Standardize the position of all animals that are to be compared, be patient and wait for an animal to stand correctly, unforced position and Weight was measured early in the morning before their release for feeding to minimize post-prandial gut variation (Abegaz and Awgichew (2009).

CONCLUSION

Sheep and goat producers would like to know weight of their animals for various purposes. Under smallholder farmers/pastoralist live body weight of small ruminant were predicted from linear body measurement. Among linear body measurement, heart girth have strong correlation with body weight and services as independent variables to predict live body weight of small ruminant. There is positive and significant correlations between live body weight and heart girth for both sheep and goats of different

Table 3. Prediction of live body weight from heart girth of sheep in Ethiopia.

Sheep breeds	Regression model/formula		References
Breed	Female	Male	References
Horro	-	BW=-40.36+0.99HG	Kassahun (2000)
Horro	BW=36.13+0.86HG	BW=-39.96+1.03HG	Zewdu (2008)
Abergelle	BW=-20.91+0.58HG	BW=-8.13+0.43HG	Seare et al.(2011)
Menz	-	BW=-35.06+0.89HG	Kassahun (2000)
Menz	BW=-23.29+0.67HG	BW=-23.42+0.67HG	Getachew (2008)
Hararghe highland	BW=-22.16+0.65HG	BW=-43.24+0.94HG	Wossenie (2012)
Bonga	BW=-33.34+0.90HG	BW=-40.95+0.99HG	Zewdu (2008)
Afar	BW=-31.0+0.80HG	BW=-30.77+0.82HG	Getachew (2008)
BHS	BW=-28.42+0.80HG	BW=- 36.45+0.92HG	Wendimu (2013)
Gumuz	BW= 26.44+0.76HG	BW= -50 +1.08HG	Solomon (2007)
Local of Eat Gojam	BW= -5.20+0.44HG	-	Michael (2013)
Local sheep of Tigray highland	BW=-15.76+0.56HG	BW=-22.36+0.68 HG	Alemayehu and Tikabo (2010)
Local sheep of North Wollo Zone	BW=-1.36+0.37HG	BW=-1.28+0.39HG	Tassew et al. (2015)

Table 4. Prediction of live body weight from heart girth of goats in Ethiopia.

Goat breeds/local population	Regression model/formula		References
	Female	Male	
Begayit	BW=-48.33+1.21HG	BW=-60.61+1.29HG	Gebrekiros et al.(2016)
Hararghe Highland	BW=-31.42+0.83HG	BW=-36.21+0.92HG	Dereje et al. (2013)
Short-eared Somali	BW=-22.3+0.67HG	BW=-25.7+0.72HG	Grump (2010)
Woyito-Guji	BW=-28.20+0.74HG	BW=39.12+0.88HG	Yaekob et al. (2015)
Central Highland			
Abergelle	BW=-21.42+0.65HG	BW=-21.72+0.67HG	Alemayehu et al.(2012)
Local goat of Bale zone	BW=-16.24+0.63HG	BW=-19.27+0.67HG	Belete (2013)
Local goat of Shabelle zone	BW=-50.35+1.11HG	BW=-63.45+1.3HG	Alefe (2014)
Local goat of Nuer zone	BW=-24.94+0.72HG	BW=-11.08+0.53HG	Tsigabu (20150

breeds and locations. Using these correlations, body weight can be estimated from heart girth more accurately.

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